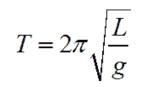
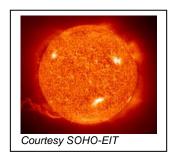
Any collection of matter that is governed by the force gravity has a natural period of oscillation. For example, a simple pendulum such as a playground swing, will move back and forth with a time period in seconds, T, defined by the formula to the right, where L is the length of the swing in centimeters, and g is the acceleration of gravity at Earth's surface given by 980 cm/sec². The period of a swing that is 3 meters long is then T=3.5 seconds.

This behavior also applies to any body held together by gravity whether it is a star or a planet. The natural oscillation period of such bodies is given by the formula to the right, where D is the density of the body in grams/cm³ and G is the Newtonian constant of Gravity

 $G = 6.6 \times 10^{-8}$ and T is in seconds. For example, the planet Jupiter has a density of about 1.3 gm/cm³ so its period will be about 10,500 seconds or T = 3 hours. From the information below, calculate the natural periods for the various astronomical bodies.



$$T^2 = \begin{array}{c} 3 \pi \\ ---- \\ G D \end{array}$$



The sun is about 1.5 million kilometers across, and has an average density near its surface of about 10⁻⁷ grams/cm³

The Earth has a diameter of about

12,500 kilometers, and has an

average density of about 5.5

grams/cm³

T = _____ hours.



Since 1964, astronomers have studied objects called pulsars. These objects change their brightness from about once a second to 30 times a second in a periodic manner.

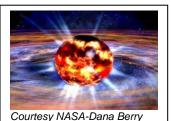
What would be a candidate object for a pulsar if the pulsar changes were due to pulsation?

What would be a candidate object of the brightness variations were due to the rotation of the body, and how does this relate to break-up speed?

Star break-up speed : 500 km/sec

Planet break-up speed : 10 km/sec





A neutron star is about 50 kilometers in diameter, and has an average density of about 2 x 10¹⁴ grams/cm³

T = seconds.

Answer Key:

The sun is about 1.5 million kilometers across, and has an average density near its surface of about 10⁻⁷ grams/cm³

$$T = 3.7 \times 10^7$$
 seconds
= 10,500 hours.

The Earth has a diameter of about 12,500 kilometers, and has an average density of about $5.5 \, \mathrm{grams/cm}^3$

T = 85 minutes.

A neutron star is about 50 kilometers in diameter, and has an average density of about 2 x 10¹⁴ grams/cm³

T = 0.001 seconds.

Inquiry Question.

Students will probably GOOGLE 'pulsars' and learn that they are neutron stars. They should, however, notice that for pulsation, only neutron stars have a period (0.001 seconds) that is close enough to the 1 second to 0.033 second brightness changes cited for pulsars. Planets and stars are just too low-density to make pulsations that fast.

Rotating bodies cannot spin faster than their break up speed. For a star like the sun, this is about 500 km/sec, and for planets like earth is about 10 Km/sec. These speeds are too low to allow normal stars and planets to cause the fast pulsar changes.